

# Symptom Burden in Patients with Acute Coronary Syndrome After Percutaneous Coronary Intervention: A Network and Latent Profile Analysis

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**Purpose:** To describe the network structure and heterogeneity of symptom burden in patients with acute coronary syndrome (ACS) after percutaneous coronary intervention (PCI), and to examine factors associated with different symptom burden profiles to inform risk-stratified management after PCI.

**Patients and Methods:** A convenience sample of 261 patients with ACS who underwent PCI at a tertiary hospital in Chongqing between November 2024 and August 2025 was recruited. Data were collected using a demographic questionnaire, the Cardiac Symptom Survey, and the Seattle Angina Questionnaire. Network analysis was conducted to identify inter-symptom associations and the structural characteristics of the symptom network. Latent profile analysis (LPA) was performed to classify symptom burden patterns, and multinomial logistic regression analysis was used to explore factors associated with profile membership.

**Results:** Network analysis indicated that depression was the most central symptom (strength  $r_s = 0.886$ ). Latent profile analysis identified three distinct symptom burden profiles: Low Symptom Burden (64.0%), Moderate Symptom Burden with Prominent Access-Site Pain (12.3%), and High Symptom Burden (23.8%). Body mass index (BMI) was a significant independent predictor of symptom burden; compared with patients with normal BMI, those who were overweight or obese were significantly more likely to belong to the High ( $OR = 2.47$ , 95%  $CI$ : 1.31–4.67) or Moderate ( $OR = 2.41$ , 95%  $CI$ : 1.04–5.59) burden groups. Furthermore, higher symptom burden was significantly associated with reduced health-related quality of life, particularly regarding angina frequency and disease perception ( $P < 0.05$ ).

**Conclusion:** Symptom burden in patients with ACS after PCI demonstrates substantial individual heterogeneity. Depression occupies a central position within the symptom network, and BMI is associated with moderate and high symptom burden profiles. These findings suggest that integrating symptom network characteristics and BMI status into post-PCI assessment may facilitate risk-stratified management and targeted psychological and weight-related interventions to improve recovery outcomes.

**Keywords:** acute coronary syndrome, percutaneous coronary intervention, network analysis, latent profile analysis, symptoms, symptom management

## Introduction

According to projections by the American Heart Association (AHA), cardiovascular disease will remain one of the leading causes of death and disease burden worldwide by 2035.<sup>1</sup> Acute coronary syndrome (ACS) is the most common and severe manifestation of coronary heart disease, characterized by sudden onset, rapid progression, and high mortality.<sup>2</sup> Although percutaneous coronary intervention (PCI), as a major revascularization strategy, has significantly improved patient survival, restoration of coronary blood flow does not necessarily lead to complete symptom relief.<sup>3</sup> Previous studies have shown that approximately 20–40% of patients continue to experience residual or recurrent ischemic

symptoms during the early post-PCI period.<sup>4–6</sup> In addition, psychological symptoms such as anxiety, depression, and sleep disturbances,<sup>7</sup> as well as physical symptoms such as access-site pain,<sup>8,9</sup> are frequently reported. These symptoms rarely occur in isolation but tend to interact and form symptom clusters, thereby increasing overall symptom burden and adversely affecting post-PCI recovery.<sup>10</sup>

Previous studies on post-PCI symptoms in patients with ACS have primarily assessed symptom experiences using individual symptoms or total questionnaire scores. However, traditional classification or dimensionality reduction approaches may overlook the complex interactions among symptoms and fail to capture heterogeneity in symptom experiences across patients.<sup>11–15</sup> Network analysis provides a novel perspective for symptom science research.<sup>16</sup> By examining network structures, nodes, and their connections, this approach can reveal the relational structure among symptoms and identify symptoms occupying central positions within the network.<sup>17</sup> These central symptoms, characterized by high centrality, may play key roles in driving the overall symptom system. Latent profile analysis (LPA), a person-centered analytical method, classifies individuals into distinct latent subgroups based on multidimensional symptom patterns.<sup>18,19</sup>

Identifying factors associated with different symptom burden subgroups is important for precision-oriented nursing management. Previous research suggests that demographic and clinical characteristics may influence symptom experiences and recovery trajectories. Body mass index (BMI), which is closely related to inflammation, metabolic dysregulation, and cardiovascular prognosis, may contribute to heterogeneity in symptom burden.<sup>20,21</sup> In addition, health-related quality of life, an important patient-centered outcome, is closely associated with symptom burden.

Accordingly, this study aimed to identify central symptoms and latent symptom burden subgroups in patients with ACS during the post-PCI period using symptom network analysis and latent profile analysis. In addition, the study examined the association between BMI and latent profile membership and compared quality-of-life differences across subgroups to inform precision-oriented symptom management.

## Materials and Methods

### Design and Participants

A convenience sample of ACS patients who underwent PCI at the Department of Cardiology of a tertiary hospital in Chongqing between November 2024 and August 2025 was recruited. Inclusion criteria were as follows: (1) age  $\geq 18$  years; (2) diagnosed with ACS according to the Chinese Guideline for the Diagnosis and Treatment of ACS and undergoing PCI for the first time.<sup>22</sup> (3) fully conscious and able to communicate and comprehend written information; (4) provided written informed consent and voluntarily participated in the study. Exclusion criteria were: (1) severe hepatic or renal dysfunction, malignancy, or other terminal diseases; (2) severe visual or hearing impairment, or psychiatric disorders.

### Sample Size

Based on Kendall's principle for sample size estimation, the sample should be 5–10 times the number of independent variables.<sup>23</sup> With 17 independent variables, the required sample size was 90–180. Considering a potential 20% invalid response rate, the planned recruitment target was 113–225 participants. For symptom network analysis, which included 10 symptoms, only symptoms with  $\geq 25\%$  prevalence were included.<sup>24,25</sup> Preliminary data indicated that 9 symptoms met this criterion. The network model required estimation of 9 threshold parameters and 36 pairwise association parameters, totaling 45 parameters. Accounting for a 20% invalid response rate, the minimum sample size for network analysis was 57. Ultimately, 261 ACS patients post-PCI were included.

## Instruments

### Demographic and Clinical Characteristics

Demographic and clinical data were collected using a self-designed questionnaire. Sociodemographic variables included sex, age, body mass index (BMI), educational level, occupation, residence, and medical payment method. Clinical

variables included ACS type, number of stents implanted, comorbid hypertension and diabetes, smoking and alcohol history, Killip classification, and left ventricular ejection fraction (LVEF).

### Cardiac Symptom Survey (CSS)

Patients' symptom burden was assessed using the Cardiac Symptom Survey (CSS) developed by Nieveen et al<sup>26</sup> The CSS comprises two dimensions: symptom assessment and response to symptoms, covering 10 cardiac-specific symptoms (chest pain, shortness of breath, fatigue, depression, sleep disturbance, access-site pain, leg swelling, chest tightness, anxiety, and poor appetite), plus one open-ended item. Symptom assessment scores reflect both frequency and severity, calculated as the mean of the two. The Chinese version has demonstrated good reliability and validity (Cronbach's  $\alpha = 0.870$ ).<sup>27</sup> In the present study, the Cronbach's  $\alpha$  coefficient was 0.673, indicating acceptable internal consistency.

### Seattle Angina Questionnaire (SAQ)

Health-related quality of life was assessed using the Seattle Angina Questionnaire (SAQ).<sup>28</sup> The SAQ contains five dimensions: physical limitation, angina stability, angina frequency, treatment satisfaction, and disease perception, comprising 19 items. Dimension scores were converted to a 0–100 scale: Standard Score = (observed score – minimum score) / (maximum score – minimum score)  $\times$  100, with higher scores indicating better quality of life and functional status. The Chinese version has demonstrated good reliability (Cronbach's  $\alpha = 0.759$ ).<sup>29</sup> In this study, the Cronbach's  $\alpha$  coefficient was 0.709, indicating acceptable internal consistency.

## Data Collection and Quality Control

Symptom data were collected at one month post-PCI, a time point when patients have typically completed acute-phase or staged treatments and entered a relatively stable recovery stage, enabling a comprehensive assessment of postoperative symptom burden.<sup>22,30</sup> After obtaining informed consent, symptom-related information was collected through face-to-face interviews. The questionnaire completion process was guided on site by uniformly trained and standardized researchers. All completed questionnaires were collected immediately and reviewed individually. Questionnaires with substantial missing data, logical inconsistencies, or patterned responses were excluded to ensure data quality. Demographic characteristics, clinical data, and laboratory examination results were extracted from the hospital electronic medical record system. All data were independently double-entered by two researchers and cross-checked for consistency to ensure accuracy and reliability.

## Statistical Analysis

Only symptoms with a prevalence of  $\geq 25\%$  (9 symptoms) were included in the subsequent symptom network analysis and latent profile analysis (LPA).<sup>25,31</sup> Symptom network analysis was conducted using the qgraph package in R (version 4.4.0). Spearman correlations were used to estimate the association matrix among symptoms, and the network structure was estimated using the EBICglasso method. Node importance was evaluated using centrality indices, including strength, closeness, and betweenness. Strength centrality ( $rs$ ) was used as the primary indicator for identifying central symptoms due to its greater stability.<sup>32</sup>

In addition, non-parametric bootstrap procedures with 1000 iterations were performed using the bootnet package to assess the stability of edge weights and to calculate the correlation stability coefficient (CS coefficient). A CS coefficient greater than 0.5 was considered to indicate good network stability.<sup>33</sup>

Latent profile analysis (LPA) was performed using Mplus 8.3 to identify latent subgroups of symptom burden among patients after PCI. LPA is a person-centered statistical approach that classifies individuals into distinct subgroups based on similar symptom patterns.<sup>19</sup> Model fit was evaluated using multiple indices, including the Akaike information criterion (AIC), Bayesian information criterion (BIC), adjusted BIC (aBIC), entropy, and likelihood ratio tests (LMRT and BLRT). The optimal model was determined based on the overall evaluation of these indices.

Other statistical analyses were performed using SPSS version 27.0. Normally distributed continuous variables were presented as mean  $\pm$  standard deviation (SD) and compared using one-way analysis of variance (ANOVA). Non-normally distributed variables were expressed as median (interquartile range) and compared using the Kruskal–Wallis  $H$ -test.

Categorical variables were presented as n (%) and compared using the  $\chi^2$ -test. Variables with  $P < 0.05$  in univariate analyses were included in a multinomial logistic regression model with latent profile membership as the dependent variable to identify factors associated with symptom burden heterogeneity. A two-tailed  $\alpha$  level of 0.05 was considered statistically significant.

## Results

### Participant Characteristics

A total of 261 ACS patients post-PCI were included. The mean age was  $60.88 \pm 11.40$  years, with 138 patients (52.9%) aged  $<65$  years and 123 patients (47.1%) aged  $\geq 65$  years. Males accounted for 225 patients (86.2%) and females for 36 patients (13.8%). More than half of the patients ( $n = 145, 55.6\%$ ) had a BMI  $\geq 25$  kg/m<sup>2</sup>, indicating overweight or obesity. Educational levels were distributed as follows: primary school or below (33.7%), junior high school (32.6%), and high school or above (33.7%). Regarding occupation, 69 patients (26.4%) were employed, 70 (26.8%) were retired, and 122 (46.7%) engaged in other occupations. Health insurance coverage was primarily employee-based (52.9%), with the remainder covered by urban-rural resident insurance (47.1%). Most patients were married (83.9%) and resided in urban areas (68.6%). In terms of clinical characteristics, STEMI was the most common ACS type ( $n = 112, 42.9\%$ ), followed by NSTEMI ( $n = 87, 33.3\%$ ) and UA ( $n = 62, 23.8\%$ ). Multi-vessel disease predominated ( $n = 204, 78.2\%$ ). Regarding stent implantation, 171 patients (65.5%) received one stent, and 90 patients (34.5%) received  $\geq 2$  stents. Killip class I was the most frequent on admission ( $n = 215, 82.4\%$ ). Lifestyle factors and comorbidities included smoking history ( $n = 168, 64.4\%$ ), alcohol use ( $n = 109, 41.8\%$ ), hypertension ( $n = 136, 52.1\%$ ), and diabetes ( $n = 59, 22.6\%$ ). Median LVEF was 63.0% ( $P_{25}$ – $P_{75}$ ). During the follow-up period, 41 patients (15.7%) experienced repeat PCI. Detailed characteristics are presented in Table 1.

**Table 1** Demographic and Clinical Characteristics of ACS Patients Stratified by Latent Symptom Burden Profiles ( $n = 261$ )

Characteristics	Overall ( $n = 261$ )	Low Symptom Burden Group ( $n = 167$ )	Moderate Symptom Burden with Prominent Access- Site Pain Group ( $n = 32$ )	High Symptom Burden Group ( $n = 62$ )	$\chi^2/IF$	$P$
<b>Demographic characteristics</b>						
Gender					7.646	0.022
Female	36 (13.8)	17 (10.2)	9 (28.1)	10 (16.1)		
Male	225 (86.2)	150 (89.8)	23 (71.9)	52 (83.9)		
Age					7.741	0.021
< 65 years	138 (52.9)	99 (59.3)	14 (43.8)	25 (40.3)		
$\geq 65$ years	123 (47.1)	68 (40.7)	18 (56.2)	37 (59.7)		
Body mass index (BMI)					9.349	0.009
< 25 kg/m <sup>2</sup>	116 (44.4)	86 (51.5)	10 (31.2)	20 (32.3)		
$\geq 25$ kg/m <sup>2</sup>	145 (55.6)	81 (48.5)	22 (68.8)	42 (67.7)		
Education level					12.517	0.014
High school or above	88 (33.7)	69 (41.3)	5 (15.6)	14 (22.6)		
Junior high school	85 (32.6)	49 (29.3)	13 (40.6)	23 (37.1)		
Primary school or below	88 (33.7)	49 (29.3)	14 (43.8)	25 (40.3)		
Occupation					7.944	0.094
Employed	69 (26.4)	52 (31.1)	3 (9.4)	14 (22.6)		
Retired	70 (26.8)	40 (24.0)	10 (31.2)	20 (32.3)		
Other	122 (46.7)	75 (44.9)	19 (59.4)	28 (45.2)		

(Continued)

Table 1 (Continued).

Characteristics	Overall (n = 261)	Low Symptom Burden Group (n = 167)	Moderate Symptom Burden with Prominent Access- Site Pain Group (n = 32)	High Symptom Burden Group (n = 62)	$\chi^2/H$	P
Health insurance types					3.834	0.147
Employee medical insurance	138 (52.9)	85 (50.9)	14 (43.8)	39 (62.9)		
Urban–rural resident	123 (47.1)	82 (49.1)	18 (56.2)	23 (37.1)		
insurance						
Marital status					1.251	0.535
Married	219 (83.9)	139 (83.2)	29 (90.6)	51 (82.3)		
Unmarried	42 (16.1)	28 (16.8)	3 (9.4)	11 (17.7)		
Residence					1.483	0.476
Urban	179 (68.6)	116 (69.5)	19 (59.4)	44 (71.0)		
Rural	82 (31.4)	51 (30.5)	13 (40.6)	18 (29.0)		
<b>Clinical characteristics</b>						
ACS type					2.497	0.645
STEMI	112 (42.9)	72 (43.1)	14 (43.8)	26 (41.9)		
NSTEMI	87 (33.3)	60 (35.9)	9 (28.1)	18 (29.0)		
Unstable angina	62 (23.8)	35 (21.0)	9 (28.1)	18 (29.0)		
Number of stents					1.063	0.588
1 stent	171 (65.5)	113 (67.7)	19 (59.4)	39 (62.9)		
≥2 stents	90 (34.5)	54 (32.3)	13 (40.6)	23 (37.1)		
Vascular lesions					1.303	0.521
Single–vessel lesion	57 (21.8)	36 (21.6)	5 (15.6)	16 (25.8)		
Multivessel lesion	204 (78.2)	131 (78.4)	27 (84.4)	46 (74.2)		
Killip class					0.770	0.680
I	215 (82.4)	140 (83.8)	25 (78.1)	50 (80.6)		
≥II	46 (17.6)	27 (16.2)	7 (21.9)	12 (19.4)		
Alcohol consumption					5.130	0.077
Yes	109 (41.8)	78 (46.7)	9 (28.1)	22 (35.5)		
No	152 (58.2)	89 (53.3)	23 (71.9)	40 (64.5)		
Smoking history					9.887	0.007
Yes	168 (64.4)	118 (70.7)	14 (43.8)	36 (58.1)		
No	93 (35.6)	49 (29.3)	18 (56.2)	26 (41.9)		
Comorbid hypertension					1.804	0.406
Yes	136 (52.1)	83 (49.7)	20 (62.5)	33 (53.2)		
No	125 (47.9)	84 (50.3)	12 (37.5)	29 (46.8)		
Comorbid diabetes mellitus					0.727	0.695
Yes	59 (22.6)	35 (21.0)	8 (25.0)	16 (25.8)		
No	202 (77.4)	132 (79.0)	24 (75.0)	46 (74.2)		
LVEF, % (median [IQR])	63.0 (56.5,68.0)	63.0 (57.0,68.5)	61.0 (56.0,67.0)	62.0 (56.0,68.0)	1.333	0.514

**Notes:** Values are presented as n (%) unless otherwise indicated. Continuous variables with non-normal distributions are presented as median (interquartile range, IQR) and were compared using the Kruskal–Wallis H-test. Categorical variables were compared using the chi-square test. Hypertension and diabetes mellitus are comorbid conditions.

**Abbreviations:** ACS, acute coronary syndrome; UA, Unstable Angina; STEMI, ST-segment elevation myocardial infarction; NSTEMI, Non-ST-segment elevation myocardial infarction; LVEF, Left Ventricular Ejection Fraction; BMI, Body Mass Index; IQR, interquartile range.

## Overall Symptom Burden in ACS Patients Post-PCI

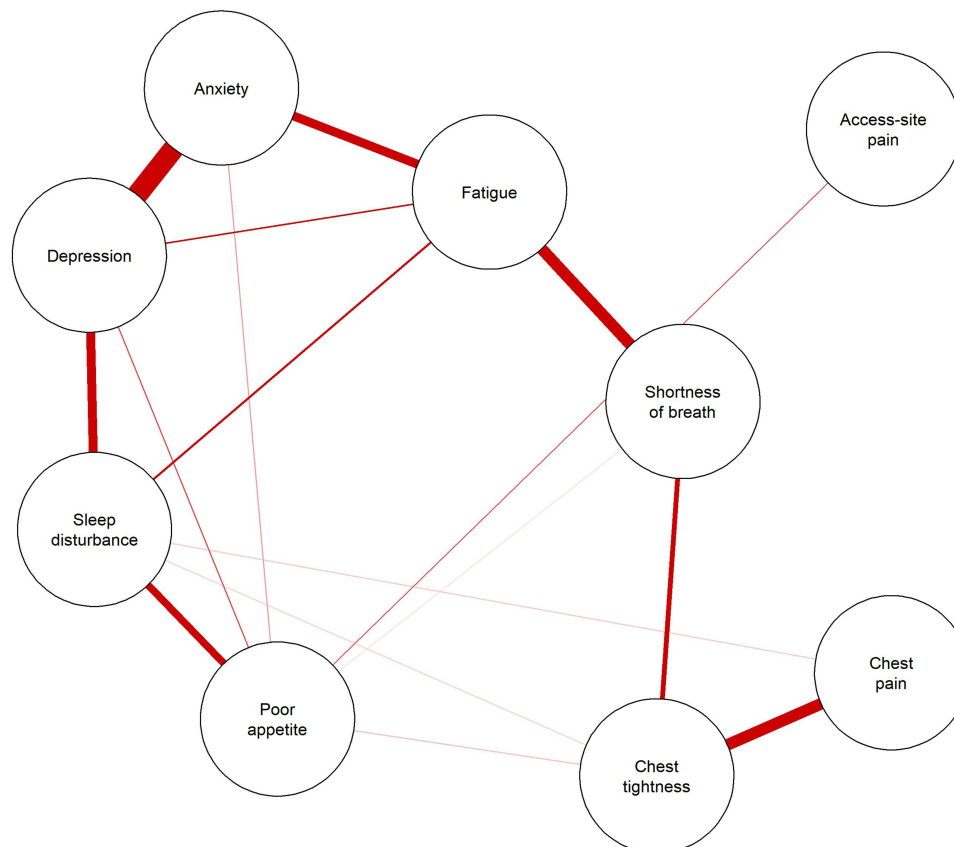
At one month post-PCI, symptom burden assessed using the CSS was dominated by psychological and systemic symptoms, whereas classical cardiac-specific symptoms were less frequent. The most prevalent symptoms were anxiety (89.7%) and fatigue (89.3%), followed by depression (77.8%) and sleep disturbance (64.8%). Poor appetite was reported

by 50.2% of patients. Classical cardiac symptoms occurred less frequently: shortness of breath (39.1%), chest tightness (35.6%), and chest pain (23.0%). Access-site pain was reported by 15.7% of patients, and leg swelling was the least frequent symptom (4.2%). These findings indicate considerable heterogeneity in Post-PCI symptom experiences, supporting subsequent application of symptom network and latent profile analyses.

## Network Analysis of Symptom Burden in ACS Patients Post-PCI

The symptom network structure is illustrated in Figure 1. The network included 9 symptom nodes, with red edges representing positive correlations and blue edges representing negative correlations. Most symptoms were positively correlated. The strongest correlations were observed between anxiety and depression ( $r = 0.454$ ), shortness of breath and fatigue ( $r = 0.287$ ), and chest pain and chest tightness ( $r = 0.283$ ).

Centrality analysis revealed that depression exhibited the highest strength centrality ( $r_s = 0.886$ ), indicating its central role in the network. Fatigue showed prominent betweenness and closeness centrality, suggesting it may act as a key connector between symptoms. In contrast, chest pain and access-site pain exhibited relatively low centrality, indicating peripheral positions within the network. Bootstrap confidence intervals demonstrated high estimation precision, and the correlation stability coefficient for strength was 0.517, indicating good network stability. These results highlight complex interrelationships among post-PCI symptoms and justify subsequent latent profile analysis to explore heterogeneity in symptom experiences. (see [Supplementary Figures 1–5](#) and [Supplementary Table 1](#)).



**Figure 1** Symptom network structure of ACS patients post-PCI.

**Notes:** Nodes represent 9 symptoms: chest pain, shortness of breath, fatigue, depression, sleep disturbance, access-site pain, chest tightness, anxiety, and poor appetite. Red edges indicate positive correlations, blue edges indicate negative correlations. Edge thickness reflects the strength of association between symptoms.

**Table 2** Fit Indices of Latent Profile Models for Symptom Burden in ACS Patients Post-PCI (n = 261)

Model	AIC	BIC	aBIC	Entropy	LMR	BLRT	Class Proportions (%)
1	10,671.77	10,735.93	10,678.86	–	–	–	100
2	10,271.89	10,371.70	10,282.93	0.996	0.0042	0.000	87.7 / 12.3
3	10,000.07	10,135.52	10,015.05	0.925	0.0007	0.000	23.8 / 64 / 12.3
4	9797.75	9968.84	9816.66	0.942	0.2864	0.000	61.7 / 23.4 / 7.7 / 7.3
5	9670.54	9877.28	9693.39	0.954	0.2834	0.000	59.4 / 14.9 / 11.1 / 7.7 / 6.9
6	9476.89	9719.28	9503.69	0.957	0.0371	0.000	61.7 / 23.4 / 4.6 / 3.8 / 3.8 / 2.7

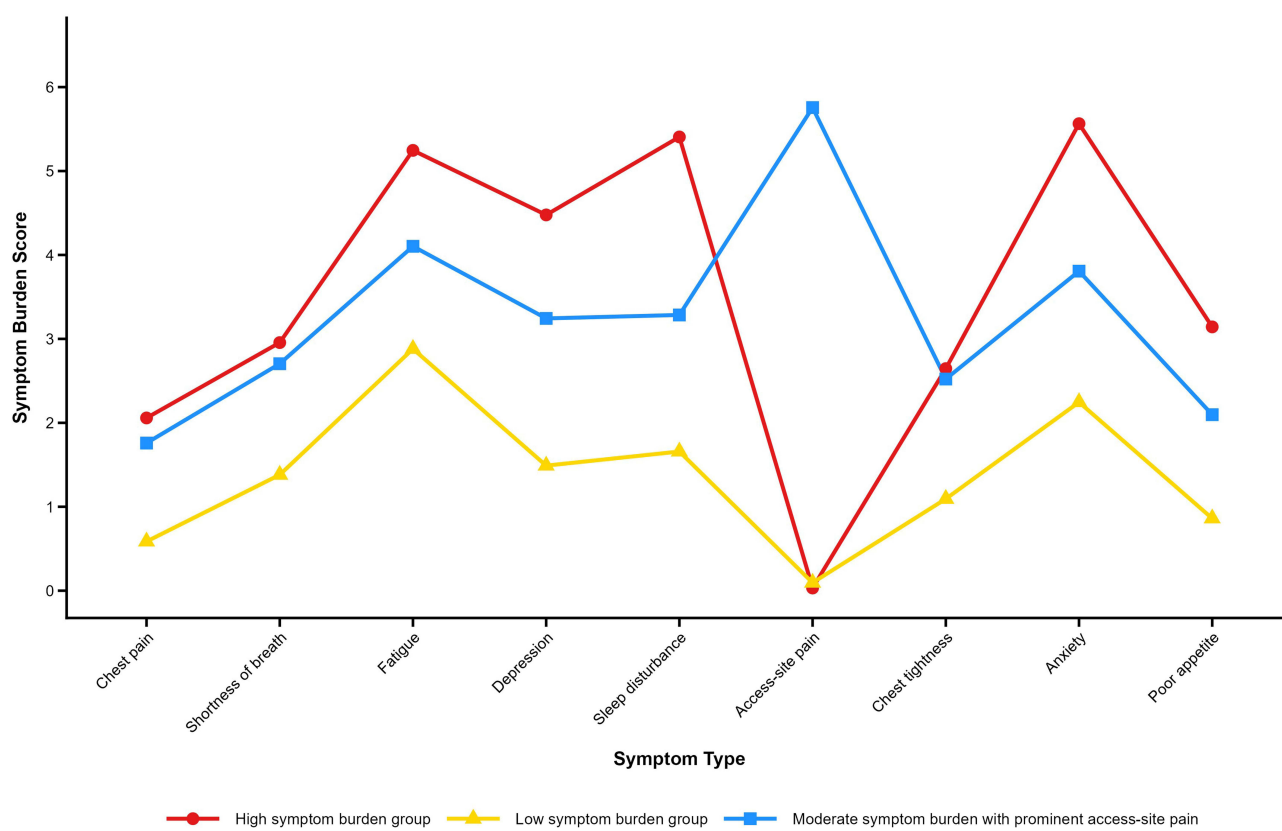
**Note:** Class proportions are presented as percentages.

**Abbreviations:** AIC, Akaike information criterion; BIC, Bayesian information criterion; aBIC, sample-size adjusted BIC; Entropy, classification accuracy (range 0–1, higher values indicate better precision); LMRT, Lo–Mendell–Rubin likelihood ratio test; BLRT, bootstrap likelihood ratio test.

## Latent Profile Analysis of Symptom Burden in ACS Patients Post-PCI

Latent profile analysis was conducted based on the scores of nine symptom dimensions. Three latent profiles of symptom burden were identified. The model fit indices for different class solutions are presented in Table 2. Considering the information criteria (AIC, BIC, and adjusted BIC), classification accuracy (entropy), and clinical interpretability of the models, the three-class model was determined to be the optimal solution. The entropy value of this model was 0.925, indicating high classification accuracy, and the proportions of the three classes were reasonable (23.8%, 64.0%, and 12.3%). In comparison, the four- and five-class models did not show meaningful improvement in model fit, whereas the six-class model contained a very small class (2.7%), which limited its clinical interpretability. Therefore, the three-class model was selected for subsequent analyses.

The mean symptom scores of the three latent profiles are presented in Figure 2. Class 1 (n = 62, 23.8%) exhibited high scores across all symptom dimensions, indicating widespread and severe symptom burden, and was therefore



**Figure 2** Mean symptom scores across 3 latent profiles of ACS patients post-PCI.

**Note:** Scores represent mean values for each symptom dimension.

labeled the High Symptom Burden Group. Class 2 ( $n = 167$ , 64.0%) exhibited consistently low scores across all symptom dimensions and was labeled the Low Symptom Burden Group. Class 3 ( $n = 32$ , 12.3%) showed a moderate overall symptom burden, with relatively higher scores for access-site pain, and was labeled the Moderate Symptom Burden with Prominent Access-Site Pain Group.

## Univariate Analysis of Latent Symptom Burden Profiles in ACS Patients Post-PCI

Univariate analysis revealed significant differences among latent profile groups in gender, age, BMI, education level, and smoking history ( $P < 0.05$ ). No significant differences were observed in occupation, insurance type, marital status, residence, ACS type, stent number, vessel disease, Killip class, alcohol use, hypertension, or diabetes (all  $P > 0.05$ ). Detailed results are presented in [Table 1](#).

## Multivariate Analysis of Latent Symptom Burden Profiles in ACS Patients Post-PCI

Multinomial logistic regression was performed using the 3 latent profiles as the dependent variable, with the Low Symptom Burden Group as the reference. After controlling for demographic and lifestyle variables, only BMI remained statistically significant ( $P < 0.05$ ), suggesting it as an independent predictor of latent profile membership. Compared with patients with BMI  $< 25$  kg/m<sup>2</sup>, overweight or obese patients were more likely to be classified into the Moderate Symptom Burden with Predominant Access-Site Pain Group ( $OR = 2.41$ , 95%  $CI$ : 1.04–5.59,  $P = 0.040$ ) and the High Symptom Burden Group ( $OR = 2.47$ , 95%  $CI$ : 1.31–4.67,  $P = 0.005$ ). No statistically significant associations were found between sex, age, educational level, or smoking history and latent profile membership (all  $P > 0.05$ ). Detailed results are presented in [Table 3](#).

## Comparison of Health-Related Quality of Life Across Latent Symptom Burden Profiles in ACS Patients Post-PCI

Differences in SAQ dimensions among the 3 latent profile groups are summarized in [Table 4](#). Significant differences were observed in 4 dimensions: angina stability, angina frequency, treatment satisfaction, and disease perception (all  $P < 0.05$ ).

**Table 3** Multinomial Logistic Regression Analysis of Factors Associated with Latent Symptom Burden Profiles in ACS Patients Post-PCI

Variable	B	SE	Wald $\chi^2$	P	OR (95% CI)
<b>Moderate Symptom Burden with Prominent Access-site Pain</b>					
Intercept	-2.284	0.756	9.127	0.003	—
BMI ( $\geq 25$ kg/m <sup>2</sup> vs $< 25$ kg/m <sup>2</sup> )	0.880	0.429	4.211	0.040	2.41 (1.04–5.59)
Sex (male vs female)	-0.382	0.588	0.421	0.516	0.68 (0.22–2.16)
Age ( $\geq 65$ years vs $< 65$ years)	0.163	0.442	0.136	0.712	1.18 (0.50–2.80)
Educational level (primary school or below vs high school or above)	1.071	0.606	3.127	0.077	2.92 (0.89–9.57)
Educational level (junior high school vs high school or above)	1.117	0.588	3.614	0.057	3.06 (0.97–9.68)
Smoking history (yes vs no)	-0.771	0.492	2.453	0.117	0.46 (0.18–1.21)
<b>High Symptom Burden Group</b>					
Intercept	-2.091	0.602	12.064	0.001	—
BMI ( $\geq 25$ kg/m <sup>2</sup> vs $< 25$ kg/m <sup>2</sup> )	0.905	0.324	7.789	0.005	2.47 (1.31–4.67)
Sex (male vs female)	0.046	0.524	0.008	0.930	1.05 (0.38–2.92)
Age ( $\geq 65$ years vs $< 65$ years)	0.586	0.342	2.938	0.087	1.80 (0.92–3.51)
Educational level (primary school or below vs high school or above)	0.658	0.421	2.444	0.118	1.93 (0.85–4.41)
Educational level (junior high school vs high school or above)	0.645	0.413	2.431	0.119	1.91 (0.85–4.28)
Smoking history (yes vs no)	-0.321	0.379	0.719	0.396	0.73 (0.35–1.52)

**Note:** OR indicates odds ratio. The low symptom burden group was used as the reference category. BMI was categorized using  $< 25$  kg/m<sup>2</sup> as the reference group, with  $\geq 25$  kg/m<sup>2</sup> defined as overweight or obesity. Sex was coded with females as the reference group. Age was coded with  $< 65$  years as the reference group. Educational level was coded with high school or above as the reference group. Smoking history was coded with no history of smoking as the reference group. Variable coding was as follows: BMI (0 =  $\geq 25$  kg/m<sup>2</sup>, 1 =  $< 25$  kg/m<sup>2</sup>), sex (0 = male, 1 = female), age (0 =  $\geq 65$  years, 1 =  $< 65$  years), educational level (0 = primary school or below, 1 = junior high school, 2 = high school or above), and smoking history (0 = yes, 1 = no).

**Table 4** Comparison of Health-Related Quality of Life Among Latent Symptom Burden Profiles in ACS Patients Post-PCI

Variable	Overall (n = 261)	Low Symptom Burden Group (n = 167)	Moderate Symptom Burden with Prominent Access-Site Pain (n = 32)	High Symptom Burden Group (n = 62)	H	P
S1	53.33 (46.67, 75.56)	53.33 (46.67, 75.56)	53.33 (46.67, 74.44)	53.33 (44.44, 75.56)	1.379	0.502
S2	100.00 (75.00, 100.00)	100.00 (75.00, 100.00)	75.00 (75.00, 100.00)	75.00 (75.00, 100.00)	35.360	<0.001
S3	100.00 (70.00, 100.00)	100.00 (80.00, 100.00)	90.00 (60.00, 100.00)	80.00 (60.00, 100.00)	16.217	<0.001
S4	87.50 (78.13, 93.75)	87.50 (81.25, 100.00)	87.50 (78.13, 87.50)	81.25 (62.50, 87.50)	25.000	<0.001
S5	50.00 (33.33, 58.33)	50.00 (33.33, 58.33)	41.67 (33.33, 58.33)	33.33 (25.00, 50.00)	9.147	0.010

**Notes:** S1, physical limitation; S2, angina stability; S3, angina frequency; S4, treatment satisfaction; S5, disease perception. Scores range from 0 to 100, with higher scores indicating better quality of life.

No significant differences were found in the physical limitation dimension ( $P = 0.502$ ). These findings indicate that latent profiles of symptom burden are associated with differential impacts on patients' health-related quality of life.

## Discussion

This study explored the symptom network structure and latent symptom burden profiles in patients with acute coronary syndrome (ACS) following percutaneous coronary intervention (PCI). Three major findings were identified. Depression emerged as the core symptom in the post-PCI symptom network, while fatigue primarily functioned as a bridging symptom linking multiple symptom nodes. In addition, latent profile analysis revealed three distinct symptom burden subgroups characterized by low, moderate, and high symptom burden patterns, indicating substantial heterogeneity in post-PCI symptom experiences. Furthermore, body mass index (BMI) was identified as an independent predictor of symptom burden profiles, with overweight or obese patients being more likely to experience moderate or high symptom burden. Together, these findings underscore the complexity of symptom interactions and highlight the need for individualized symptom assessment and targeted nursing interventions for ACS patients after PCI.

## Symptom Network and Core Symptoms in ACS Patients Post-PCI

Fatigue was the most prevalent symptom in ACS patients post-PCI, with an incidence of 30–76% in cardiovascular populations.<sup>34,35</sup> In the present study, fatigue primarily referred to physical fatigue, characterized by persistent exhaustion, low energy, and physical weakness. When persistent, fatigue may contribute to endocrine dysfunction, reduced physiological function, and accelerated disease progression, ultimately impairing quality of life.<sup>36</sup> Despite its high prevalence, fatigue was not a core node in the symptom network. Instead, it demonstrated prominent betweenness and closeness centrality, suggesting that it may function as a bridging symptom connecting different symptom nodes within the network. Previous studies have shown that fatigue often diminishes over time, and systematic cardiac rehabilitation can substantially improve functional recovery and alleviate symptoms.<sup>37</sup> Therefore, clinicians should dynamically monitor fatigue during hospitalization and early after discharge, with particular attention to patients exhibiting slow recovery or severe symptoms, and implement personalized interventions to enhance overall rehabilitation outcomes.

Depression emerged as the core symptom in the post-PCI symptom network, ranking highest in strength centrality, indicating its pivotal role in maintaining the overall symptom system. Post-PCI patients commonly face risks of disease recurrence, restenosis, and uncertain prognosis,<sup>38</sup> which can induce negative emotional responses such as anxiety and depression.<sup>39,40</sup> Depression may increase the risk of cardiovascular events by reducing treatment adherence and weakening self-management abilities, while PCI-related physiological stress responses (eg, sympathetic activation and enhanced inflammatory activity) may further exacerbate psychological burden. Previous studies have demonstrated

a significant correlation between depression and fatigue, suggesting a close interaction within the symptom network.<sup>41,42</sup> Core symptoms maintain strong connections with multiple nodes and exert disproportionate effects on other symptoms; thus, interventions targeting depression may trigger cascading effects across the network, alleviating both psychological and somatic symptoms. Clinicians should integrate routine emotional assessment into follow-up care and systematically incorporate psychological support into post-PCI symptom management, including narrative nursing, acceptance and commitment therapy, and patient group sessions, to reduce psychological stress, enhance resilience, and improve rehabilitation outcomes.

## Latent Symptom Burden Profiles in ACS Patients Post-PCI

Latent profile analysis identified three symptom burden subgroups with distinct clinical characteristics, indicating substantial heterogeneity in post-PCI symptom experiences among ACS patients. These findings are consistent with Abbott et al<sup>43</sup> in elderly patients undergoing coronary artery bypass grafting, further supporting the clinical value of patient-centered symptom profiling in cardiovascular disease management and providing a foundation for precision and stratified interventions. By identifying different symptom burden patterns, the present study further revealed individual variations in symptom experiences after PCI.<sup>10</sup>

The Low Symptom Burden Group (C2, 64.0%) exhibited generally low physical symptoms, although fatigue and psychological symptoms remained prevalent. Even in this low-burden subgroup, potential psychological stress responses should be closely monitored. Clinical management may benefit from interventions focusing on stress reduction, secondary prevention, and enhancement of self-management abilities to prevent symptom persistence or recurrence.<sup>44,45</sup>

The Moderate Symptom Burden with Predominant Access-Site Pain Group (C3, 12.3%) showed an overall moderate symptom burden, with access-site pain being particularly prominent. Notably, some patients in this subgroup underwent repeat PCI within one month after discharge, suggesting that repeated vascular punctures and perioperative procedures may be associated with a symptom pattern dominated by localized pain. Repeated vascular access and perioperative manipulation may increase local tissue irritation and nociceptive stimulation, thereby contributing to the prominence of access-site pain in this subgroup. Although access-site pain is not a core node in the symptom network, it may amplify the overall symptom burden. Previous studies have reported that puncture-site pain is an important node within the symptom network during the first 48 hours post-PCI, being significantly associated with precordial pain and potentially predictive of postoperative complications.<sup>46</sup> Prospective pain assessment and individualized management, including optimized hemostasis, pain education, and analgesic interventions, are recommended.

The High Symptom Burden Group (C1, 23.8%) was characterized by widespread and persistent physical and psychological symptoms, with fatigue, anxiety, depression, and sleep disturbances being most prominent. Negative emotions in this subgroup may persist for several months, reflecting ongoing concerns regarding long-term medication adherence, disease recurrence risk, and prognostic uncertainty.<sup>39</sup> These patients exhibited markedly reduced health-related quality of life, highlighting the need for multidimensional interventions integrating psychological support, symptom management, and disease education to improve post-PCI rehabilitation outcomes.<sup>47</sup>

## Influencing Factors in ACS Patients Post-PCI

Multivariate analysis showed that BMI was an independent factor associated with latent symptom burden profiles. Patients with BMI  $\geq 25$  kg/m<sup>2</sup> were more likely to be classified into the Moderate Symptom Burden with Predominant Access-Site Pain Group and the High Symptom Burden Group, suggesting that body weight may play an important role in the development of symptom heterogeneity. Obesity is characterized by metabolic dysregulation and chronic low-grade inflammation. Excess visceral adipose tissue can continuously release pro-inflammatory cytokines, thereby triggering systemic inflammatory responses and disrupting metabolic and immune homeostasis.<sup>21,48</sup> Previous studies have shown that depression is closely associated with elevated levels of multiple inflammatory markers.<sup>20,49</sup> Combined with the findings of the symptom network analysis in the present study, BMI may enhance interactions among symptoms centered on depression through inflammation-related mechanisms, thereby increasing the likelihood that patients develop a high symptom burden pattern.

From a nursing practice perspective, weight management may serve as an important entry point for symptom management in ACS patients after PCI. Incorporating BMI into routine assessments may facilitate the early identification of patients at high risk of moderate-to-high symptom burden trajectories. Clinical nurses can consider patients' weight status when conducting systematic symptom assessments and integrate dietary guidance, exercise interventions, and psychological support into long-term management plans. Such multidimensional interventions may weaken the reinforcing interactions among core symptoms and ultimately improve patients' overall symptom experience and rehabilitation outcomes.

## Clinical Implications

By integrating symptom network analysis with latent profile analysis, this study systematically elucidated the interrelationships among post-PCI symptoms and highlighted individual heterogeneity in ACS patients. These findings provide evidence for stratified and precision symptom management. Depression occupied a central position in the post-PCI symptom network, showing strong associations with fatigue, anxiety, and sleep disturbances, suggesting that it may serve as a hub within the overall symptom system. Early identification and targeted intervention for depression may generate cascading effects within the symptom network, thereby improving multidimensional symptom management efficiency and outcomes.

Latent profile analysis revealed substantial heterogeneity in symptom burden. The Low Symptom Burden Group should focus on health education and secondary prevention. The Moderate Symptom Burden with Predominant Access-Site Pain Group requires enhanced perioperative and early afterdischarge pain assessment and management. The High Symptom Burden Group benefits from multidimensional interventions integrating psychological support and somatic symptom management. Additionally, BMI was identified as an important factor distinguishing moderate-to-high symptom burden subtypes and may aid in identifying high-risk patients. Incorporating BMI into early post-PCI assessment, combined with weight management, inflammation control, and psychological interventions, can reduce overall symptom burden and improve rehabilitation outcomes. Collectively, this study establishes a clinical decision-making pathway from core symptom identification to patient stratification and high-risk screening, providing both theoretical and practical guidance for precision symptom management in ACS patients post-PCI.

## Limitations

Several limitations should be acknowledged. First, this study employed a single-center cross-sectional design with a relatively limited sample size. Although the total sample size met the minimum theoretical requirements for multinomial logistic regression, the small number of cases in certain latent subgroups (eg, the Moderate Symptom Burden group) may affect the stability of parameter estimates and limit the generalizability of the findings. Second, symptom assessments were conducted only at one month post-PCI, which does not capture dynamic changes in symptom burden over the mid-to-long term, limiting inferences about causal relationships or temporal evolution among symptoms. Third, while clinical theory suggests that patients presenting with acute myocardial infarction (STEMI/NSTEMI) may experience a greater residual symptom burden due to their emergent condition, our study did not observe a statistically significant association between ACS subtype and latent profile membership. This highlights the need for further investigation into how initial disease severity impacts individual symptom trajectories. Finally, objective biological variables, such as inflammatory markers, were not included, restricting the exploration of the underlying biological mechanisms of the symptom network. Future studies should adopt multicenter, large-sample longitudinal designs, incorporating biological and behavioral indicators as well as varied clinical presentations, to further clarify the formation mechanisms and dynamic evolution of symptom networks.

## Conclusion

This study demonstrates that depression is the core symptom in the early post-PCI symptom network of ACS patients, exerting a critical influence on the overall symptom system. Latent profile analysis further revealed significant heterogeneity in post-PCI symptom burden, identifying three clinically distinct symptom burden subtypes. Multivariate analysis indicated that body mass index is an important factor distinguishing moderate-to-high symptom burden

subtypes. Based on these findings, clinical practice may combine symptom network characteristics with patient BMI to implement stratified assessments, targeting depression management as the core, while integrating pain control and weight regulation strategies. Such individualized and comprehensive symptom management is expected to improve post-PCI rehabilitation outcomes and quality of life.

## Data Sharing Statement

The data and materials supporting the findings of this study are available from Ms. Hong Shuqin upon reasonable request. Requests may be directed to [hsq032611@163.com](mailto:hsq032611@163.com).

## Ethical Approval Statement

The study protocol was approved by the Ethics Committee of the Second Affiliated Hospital of Chongqing Medical University (2024 Research Ethics Approval No. 50). The study was conducted in accordance with the Declaration of Helsinki, and all participants provided written informed consent prior to data collection.

## Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

## Disclosure

The authors report no conflicts of interest in this work.

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